Roofing

A.I.A. File No. 12 (or Q-2.4)

ROOFING MATERIALS

HOW to designate incline of roof slopes correctly
WHAT roofing materials are suitable for different roof inclines
STANDARD sizes and weights of principal roofing materials
KINDS of hips, valleys, and ridges suitable for various unit roofings
EXPANSION of metal roofings of various types and how to provide for it
DIFFERENCES between asphalts, coal-tar pitch, tar and other bituminous roofing materials, and where to use each type
FLASHING details and principles of good practice
HOW to compute gutter and leader sizes from rainfall data
WHERE and how to use insulation and ventilation for comfort and economy

AMERICAN ARCHITECT
REFERENCE DATA
NO. 16, FEBRUARY, 1935

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FIVE things govern the selection of roofing materials for any specific building: pitch of the roof deck; weight of the roofing material or ability of an existing roof structure to support a light or heavy surfacing; initial and ultimate cost; protective value and durability; and, finally, appearance.

Often the first four of these factors are so self-evident that the designer's interest is immediately concentrated on the relative appearance values of several kinds of roofing of a given type. But when the roof pitch is in the intermediate area between flat and steep; when weight, initial cost, or durability are significant; and even when appearance factors such as texture, scale and details of assembly, must be worked out with care, a great deal of data normally scattered through many handbooks, manuals and catalogs must be available for study if the designer's final selection is to be well considered.

For convenient reference, roofing materials are here grouped into three broad classes: waterproof roofing suitable for flat- and low-pitched roof decks; sheet roofings used on pitched roofs; and unit roofings of shingle type which depend upon pitch for their water-shedding ability.

PITCH OF ROOF DECK

THREE methods of designating pitch or slope of roof decks are used and must be clearly understood by the designer.

(1) Vertical Rise in inches to each foot of horizontal run. For example—"six inches to the foot." This method is favored by carpenters because they can lay out their angles for framing the roof with an ordinary foot rule or square, and without a knowledge of trigonometry or the use of a protractor.

(2) Angle, measured in degrees and minutes, between the roof slope and the horizontal. Example: "a pitch of 45° 0′" which is the equivalent of a twelve inch rise to the foot. This method is favored in steel fabrication because of the common use of protractors and accurately graduated guides on machines employed in cutting and assembling steel framing. However, the vertical rise method can be quickly adapted by steel workers and therefore is of broader usefulness.

(3) Pitch, or height in relation to span, expressed as a fraction denoting the ratio of the total rise of the roof to its total span. Example: a roof rising 10 feet and having two equal sides spanning a total distance of 20 feet would have a "½ pitch or slope."

This method is impractical and confusing and should be abandoned. It does not apply to unequal slopes or to single slopes unless both the designer and the contractor understand that in such cases a theoretical total span equal to twice the horizontal projection of the slope is used in figuring the pitch.

Table 1 shows the angle and pitch designations for all roof slopes from dead flat to a rise of 20 inches to the foot. It also approximately indicates the limits of pitch recommended for different types of roofing materials. No fixed limits of pitch exist for each type of roof, for the permissible or required slope is influenced by both climate and design.

WEIGHT OF ROOFING MATERIALS

IN designing the roof structure of new buildings the dead weight of the roofing materials must be taken into consideration, and these vary widely as indicated in Table 2. Conversely, in existing buildings which are to be re-roofed the load bearing capacity of the present structure may definitely limit the type of roofing than can be used safely. In terms of construction cost, the heavy roofing materials can be used most economically on roofs of relatively steep pitch or short span, or both; otherwise the dead weight of the surfacing will require increased depth and decreased spacing of rafters and purlins, or increased thickness and reinforcement of concrete or other masonry slabs.

UNIT ROOFING MATERIALS

THE term "unit roofings" is here employed to designate shingles, tiles, slates, etc. which are laid as individual units and which rely upon the incline of roof and the overlap of units for shedding.

WOOD SHINGLES

ESSENTIALLY an American roofing material, wood shingles are still the predominant roofing for residences in this country. Their life varies widely according to grade of shingle, pitch of roof, exposure, climate, and subsequent maintenance. The

TABLE I. PITCH OF ROOFS

Equivalent pitch designations and approximate limits of pitch for basic types of roofing.

Equivalent Pitch: Vertical Rise inches per foot of horizontal run	Equivalent Pitch: Angle formed by slope with horizontal (nearest 5')	Equivalent Pitch: Pitch or slope. Ratio of rise to total span	Approximate Roofing Materials by Type	Per cent of roof area over plan area; less overhang
dead flat	0	0		0
1	4°45'	1/24	Coal-tar pitch and felt with slag, gravel or tile top surface or asphalt and felt, for dead flat to slight slopes according to materials and nature of roof deck.	0.34
2	9°30'	1/12		1.4
3	14° 0'	1/8		3.1
4	18°25'	1/6	Asphalt and felt built-up roofings. Special types may be used on slopes up to 9" per foot.	5.4
5	22°40'	5/24		8.3
6	26°35'	1/4		11.8
7	30°15'	7/24		15.8
8	33°40'	1/3		20.2
9	36°50'	3/8	Wood, asphalt, asbestos-cement shingles permissible on slopes from 6" per foot up, but better on slopes 10" per foot and steeper.	25.0
10	39°50'	5/12		30.2
11	42°30'	11/24		35.6
12	45° 0'	1/2		41.4
13	47°20'	13/24		47.6
14	49°20'	7/12		53.7
15	51°20'	5/8	Slate, clay tile, interlocking metal shingles and tiles.	60.0
16	53°10'	2/3		66.7
17	54°50'	17/24		73.2
18	56°20'	3/4	Copper, tin, terne-plate sheet metal roofings with soldered joints on decks under 2" - 3" pitch; lead in limited areas under 2" - 3" pitch; Above metals plus zinc and aluminum without soldered or welded seams above 2" - 3" pitch. Also canvas.	80.3
19	57°40'	19/24		87.2
20	59° 0'	5/6		94.3

normal expectancy is generally from 15 to 30 years; sometimes more. Treatment with preservatives before or after laying, and occasional treatment when they show signs of deterioration, will considerably extend their useful life. The woods used are cypress, cedar and redwood, which constitute the durable grades. White and yellow pine, and spruce make inferior shingles and are rarely used.

Wood shingles may be employed on roof inclines rising 6 or more inches per foot; some authorities recommending 8 inches to the foot as minimum. Standard sizes and approximate weights are shown in Table 2. Each of the standard lengths is made in three grades defining the minimum and the maximum width of the shingle. No. 1 shingles must be all edge-grain strictly clear and containing no sapwood. Nos. 2 and 3 grades permit slash grain and certain defects established by the grading rules.

The roof deck may be laid open or tight, the latter being preferred for greater insulation value; the former largely for economy. Wood shingles in themselves have higher insulating value than any other roofing, but the difference in cost between a tight sheathing or open sheathing is more than offset by the superior protection afforded by the solid deck.

Exposure of wood shingles is based on the rule-of-thumb method that not more than one-third of the total length shall be exposed on roofs and not more than one-half on side walls. See Table 3.

Nails used should be either hot dipped zinc-coated iron cut, hot dipped zinc-coated steel-and-copper, or copper nails in sizes shown in Table 3 or in larger sizes to give secure grip on the wood sheathing or shingle lath where hand-split heavy butt shakes are employed, or where the nails must penetrate an existing shingle roof. Specify two nails to each

TABLE II.

Comparative Roofing Data

American Architect Reference Data Number 16 "Roofing Materials" February, 1935

Kind of Roof	Materials or Type	Permissible Slope in inches per foot		Approx. Weight per 100 sq. ft. in pounds	Type of Roof Deck	Unit Sizes	Application Data
		Minimum	Maximum				
WOOD SHINGLES	Red cedar Cypress Redwood	6" preferably 10" to 12"	Vertical	200	Tight Sheathing or Shingle Lath.	Standard 16" long, 5 butts in 2" 18" " 5 " " 2¼" 24" " 4 " " 2" Shakes and specials 25" to 30" ½" to 1½" butts	For exposure data and nail sizes see Table 3.
ASPHALT SHINGLES	Asphalt saturated felt with mineral granule surfacing	6" preferably 10" to 12"	Vertical	130 - 150	Tight Sheathing	Strip shingles 10" to 13½" deep 36" wide Single units 9"x 12", 12"x 16" and manufacturer's specials	Usually laid 4" to 5" to the weather, depending on form.
ASBESTOS-CEMENT SHINGLES	Rectangular Hexagonal Dutch Lap	6" preferably 10" to 12"	Vertical	600 - 650 275 - 325 275 - 325	Tight Sheathing	6" to 16" wide, 16" - 18" long 16"x 16" average 16½"x 16½" average	2" head lap - see Table 4 About 3" lap on top edges ⅓ or ¼ side lap.
SLATE	Commercial (3/16 smooth) Textural (heavy, rough)	4" depending on lap	Vertical	3/16" 750 ¼" 900 ⅜" 1400	Tight Sheathing or Nailing Compound	Lengths, standard 12" to 24" Widths 6" to 14" depending on length.	See Table 4 for head laps and exposure to weather.
	Tile for flat roofs	Slate tile on flat roofs	1" - 2"	½" 1800 ¾" 2700 1" 3600		Other sizes on order	Flat deck tile set in compound. Weight about ½ of lapped shingles of same thickness.
CLAY TILE	Mission	4" - 6"	About 15"	1200 - 1450	Tight Sheathing with Battens	14" to 18" long, 7"- 8" wide	Lapped 3" at head
	Spanish	4" - 6"	About 15"	800 - 900	Tight Sheathing or Nailing. Compound	13" to 14" long, 9"- 10" wide	3" single head lap
	Roman and Greek	4" - 6"	About 14"	1100 - 1300		About 12½" long, - 10" wide	2¾"- 3" single head lap
	French	4" - 6"	About 15"	800 - 900		16 long, 9" wide	3" single head lap
	English	4" - 6"	About 15"	800 - 900		11"- 14" " 8"- 9" "	3" single head lap
	Shingle	6"	Vertical	1200 - 1800		12"- 16" " 6"- 8" "	2" head lap (See Table 4)
	Promenade	¼"	1" - 2"	1200 - 1500	Built-up Membrane	6"x 6", 9"x 9" to 6"x 12"	Laid in compound
METAL SHINGLES AND TILES	Tin or Terne-plate Galvanized iron Zinc Copper Aluminum Enameled iron	4" - 6" preferably 8" to 12"	According to style of roof	100 - 140 105 - 160 120 - 130 120 - 190 60 - 70 240 - 250	Tight Sheathing	Tile shapes about 10"x 14" Shingle shapes about 7"x 10" or 10"x 14" Various patterns according to manufacturer About 12"x 12"	All types are interlocking with an average head and side lap of 2". Special units made for ridges, eave starters and hips, etc. Exposure about 10" x 10"
	Cast iron	4"		1080	Purlins	24"x 52" - 3/16" thick	Interlocking - self supporting
SHEET METAL ROOFINGS	Copper	¼"	Vertical	100 - 160	Tight Sheathing	16 oz. and heavier - sheets and strips; width multiples of 2"- 96" long	See text and illustrations
	Lead	¼"		250 - 600		Hard: 2½ to 3 lbs. soft 4 to 6 lbs.	" " " "
	Zinc	2"		100 - 150		Use No. 11 zinc gauge or heavier sheet sizes same as copper.	" " " "
	Aluminum	3"		60 - 70		18 ga. 24"x 96", 30"x 96", 24"x 120" 30"x 120"	Insulate with 30# asphalt felt
	Tin or Terne-plate Galvanized iron	¼" ¼"		75 - 100 75 - 100		Usually IX (about 28 gauge) sheets 20"x 28" and 14"x 20"	See text and illustrations
BUILT-UP ROOFINGS	Asphalt and felt for sloping roofs	2"	6" Special if steeper	Smooth top 150-250 Gravel top 550-600 Slag top 450-500	Various Constructions for Each Type	Number of plies and weight of felt; also composition of felt varies according to manufacturer's specifications. Usually 2 to 3 plies bonded for 10 years; 3-4 plies, 15 years and 4-5 plies, 20 yrs.	Always follow manufacturer's specifications for exact conditions of slope, type of deck and length of life desired.
	for flat roofs	0 to ½"	3" - 4"	Smooth top 150-250 Gravel top 550-650 Slag top 450-550			
	Coal-tar Pitch and Felt for flat roofs	0	1" - 2" occasionally steeper	Gravel top 600-675 Slag top 450-575			

shingle (neither more nor less) to be covered by the next course at least 1 inch; spacing between shingles not less than 3/16" nor more than ¼"; vertical joints breaking at least 1¼".

ASPHALT SHINGLES

COMPETING with wood shingles in cost and relative durability and offering a measure of fire resistance due to the mineral surfacing commonly employed, asphalt shingles have been neglected by architects primarily because of their mechanical uniformity and often gaudy colorings. Recent trends promise the development of asphalt shingles for architectural purposes as already evidenced by shingles with extra-heavy butts to give suitable shadow lines and carefully considered surface colors having good design possibilities.

They are manufactured of strips of heavy asphalt-impregnated felt surfaced with crushed slate, stone or other mineral or manufactured granules embedded in a surface coating of asphalt. The strips are then machine stamped to shape; the common forms being square butts with slots to suggest vertical joints of shingles, elongated hexagonal or diamond butts, and individual shingles of various sizes, some with slots or special provision for interlocking the units on the roof.

Standard sizes and weights are indicated in Table 2. The normal exposure of 12-inch shingles ranges from 4 to 5 inches. The usual grades are standard weight and extra heavy (jumbo, giant, thick butt, etc.) They should be nailed with two or three large-headed galvanized, zinc-clad, or copper nails over tight boarding; nails being placed just above the line of exposure to promote rigidity.

Special types include cork-backed asphalt shingles having a layer of granulated cork embedded in asphalt on the under side; and metal-clad asphalt shingles having a top surface of lightweight sheet copper.

ASBESTOS CEMENT SHINGLES

ASBESTOS cement shingles, manufactured of a mixture of Portland cement, asbestos fibre and pigment formed under extreme pressure and suitably aged or cured, constitute a fireproof and enduring roofing material. The principal types are textured unit shingles designed to closely imitate weathered wood shingles; smoother surfaced units having the characteristic of commercial slates; and hexagonal and Dutch lap types which have no architectural precedent but require minimum lap and are consequently low in cost on the finished roof.

In the cheaper grades the color is not enduring because the surface coating is too thin and erodes or fades, leaving the natural light gray tone of the base mixture. The better grade asbestos cement shingles have substantially permanent colors. Efflorescence occasionally develops on these roofs and may show on very dark shingles or those of pronounced color.

TABLE 3. WOOD SHINGLE DATA
Based on One Square (100 sq. ft.)

	Standard Lengths		
	16"	18"	24"
Standard thickness....	5 butts 2"	5 butts 2¼"	4 butts 2"
*Bundles per square—			
—roofs	4	4	4
—side walls	4	4	3
#Exposure to weather			
—roofs	4" to 5"	4" to 5½"	6" to 7½"
—side walls	5½" to 7½"	6" to 8½"	6" to 11½"
Nail size, minimum....	3d (1¼")	3½d (1⅜")	4d (1½")
Nails required per square, approx.	3 lbs. 5" exp.	3 lbs. 5" exp.	3 lbs. 7" exp.

*Net area covered varies with exposure. Add 6% to 10% for waste.

#Varies with slope and climate; use minimum exposure on slopes under 10" to the foot and in severe climates; use greater exposure for steep slopes and where climate and rainfall are moderate.

Hexagonal and Dutch lap shingles are shaped and nail punched for a specific method of laying and when used should be installed strictly according to the manufacturer's recommendations. The Dutch lap type is a rectangular shingle laid with a 3-inch head lap and a 4 or 5-inch side lap, offering somewhat less weather protection than the hexagonal or standard shingle types.

The shingle units are laid similarly to slate; that is, with a double lap, except that with asbestos shingles the lap is usually 2 inches and vertical joints are broken at least 2 inches. An impregnated roofing felt weighing 15 lbs. per square is used under standard weight shingles and 30-lbs. under the higher quality heavy-weight thick butted shingles. Nails employed should be the same as for slates.

SLATE ROOFING

SLATE constitutes a durable, impervious, moderate cost roofing of wide architectural utility and long standing precedent. Slates employed should be considered in three ways: thickness and texture, color and permanence of color, and grade.

Thickness and texture are usually related inasmuch as the commercial slate of 3/16 inch thickness must be split from blocks that have smooth, uniform cleavage producing an effect of considerable uniformity on the roof unless laid in graduated courses and random widths. Heavier slates, as listed in Table 2, usually show a rougher surface and produce a roof having a definite texture which can be developed according to the architect's requirements by combining different thicknesses and sizes.

The design of a suitably textured slate roof is a task demanding a sympathetic understanding of precedent if the result is to be entirely satisfactory. Originally textured and graduated roofs resulted from the hand quarrying of the stone, the necessity of utilizing all thicknesses and lengths as quarried, and the purchase of the quarry output by the ton. The heavier and larger slates were laid on the lower end of the rafters over the wall supports and the

GOTTSCHO

Studies in scale, texture and contrast in unit roofings indicating scope of treatment available to designer and importance of relating roof to side-wall treatment. Left; top: Tuxedo Club, Tuxedo Park, N. Y.; office of John Russell Pope, architects. Center, Residence of M. M. Van Beuren, Middletown, R. I.; Harry T. Lindeberg, architect. Bottom, Residence of Louis Wilputte, New Rochelle, N. Y.; Julius Gregory, architect. Right; top: Residence of E. T. Gardner, Dayton, Ohio; Peabody, Wilson & Brown, architects. Bottom, Residence of Harry F. Knight, St. Louis, Mo.

smaller and lighter pieces distributed over the length of the rafters, utilizing all material with minimum waste. Artificial mixing of graded sizes and thicknesses as manufactured today does not produce a comparable effect in the hands of the average roofer unless his work is skillfully supervised.

The following color nomenclature for slate has been adopted as a simplified practice by the Bureau of Standards:

Black	Blue gray	Mottled purple and green
Blue black	Purple	Green
Gray	Purple variegated	Red

These color designations should be preceded by the word "unfading" or "weathering" according to the ultimate color effect that may be desired.

Unfading slate will hold its original color except for weathering or softening of colors due to local climatic conditions. Weathering slates will actually change color to tones of light gray, yellow and brown, and this change cannot always be predicted. The producer's classification of his slates as weathering or unfading can usually be relied upon. But because different quarries produce different kinds and grades of slate, there are limitations as to the kinds that can be obtained from any one district.

Quality is indicated by grading rules which vary with each major district but substantially the first quality are true to size and thickness and free from blemishes or ribbons. The second may be less smooth and uniform and lower qualities may contain ribbons or soft streaks which are considered as impairing the durability of roofs if the ribbons are laid exposed, though of minor importance if they do not show when laid.

All slates should be laid on roofer's felt, using 15-lb. impregnated felt for commercial thickness (3/16" slate) and 30-lb. impregnated felt on textural roofs (the term "textural" being used in the trade to indicate heavier, rough-surfaced slate roofs).

The deck should be of tight wood sheathing in frame construction, or in fireproof work of suitable nailing compound on the masonry structural slab. The felt should be laid horizontally and lapped 3 inches with the joints mopped with hot pitch on masonry or nailed on sheathing.

In slating parlance exposure is expressed by the amount that a given slate laps the second slate beneath. Proper exposure is obtained by deducting the required lap from the length of the slate used and dividing by two. For example: if the specified lap is 3 inches and the slate is 24 inches long, the exposure is $24 - 3 = 21 \div 2 = 10\frac{1}{2}$ inches.

The required lap for various slopes and the resulting exposure is shown in Table 4.

On roofs rising from 1 inch to 4 inches to the foot slate is laid without lap in roofing pitch or asphalt made for the purpose over a built-up waterproof membrane roof.

Common standard methods of forming ridges, hips and valleys are indicated in Fig. 1 but the designer is free to develop roof surfaces in wide variety providing proper lap is given at all points. All slates should be nailed with at least two large-headed wire or slaters' cut nails of copper, brass or non-corroding alloy metals.

TABLE 4. EXPOSURE OF ROOFING SLATES

Length of Slate in inches	Exposure in inches for roof inclines of. 4 to 8" per foot (4" lap)	8" to 20" per foot (3" lap)	Over 20" per foot (2" lap)
10	3	3½	4
12	4	4½	5
14	5	5½	6
16	6	6½	7
18	7	7½	8
20	8	8½	9
22	9	9½	10
24	10	10½	11

TILE ROOFING

TILE roofing units in the commonly accepted meaning of the term are made of burned clay, shale or terra cotta. The shapes characteristic of the clay tiles are produced also in asbestos cement, Portland cement, sheet metals (including galvanized iron, copper, zinc, tin and aluminum) enameled metals, glass and cast iron. Originally wood shingles were considered to be wood tiles.

There are six main types of clay tiles as follows:

Mission Tile of semi-cylindrical shape either tapered or straight-sided and laid in alternate horizontal courses with the converse and concave sides up and overlapping to form covers and pans.

Spanish Tile have a round surface and an interlocking side joint which takes the place of the concave pan in a Mission tile roof.

French Tile are flat tile with heavy flat-corrugated surface and an interlocking flush joint at the side.

English Tile are flat tile with smooth tops and interlocking side joints.

Shingle Tile are similar to slates, being of approximately ½ inch thickness and rectangular shape.

Promenade or Quarry Tile are unglazed rectangular or square flat tile, usually solid red in color, for use as a traffic surface on flat roofs over a waterproof built-up roofing membrane.

Clay tile should be hard burned if used in temperate and northern climates, the softer types manufactured and used in the tropics being insufficiently resistant to erosion and frost action for use elsewhere. All tile should be laid over 30-lb. or heavier impregnated felt and fastened with copper nails or tied with heavy copper wire. They are usually laid on roofs having a pitch exceeding 6-inch rise per foot, particularly in northern climates; if laid on somewhat flatter pitches the butts of Mission and Spanish tiles must be bedded in cement mortar, which does not allow for movement on the roof and consequently introduces danger of cracked tiles.

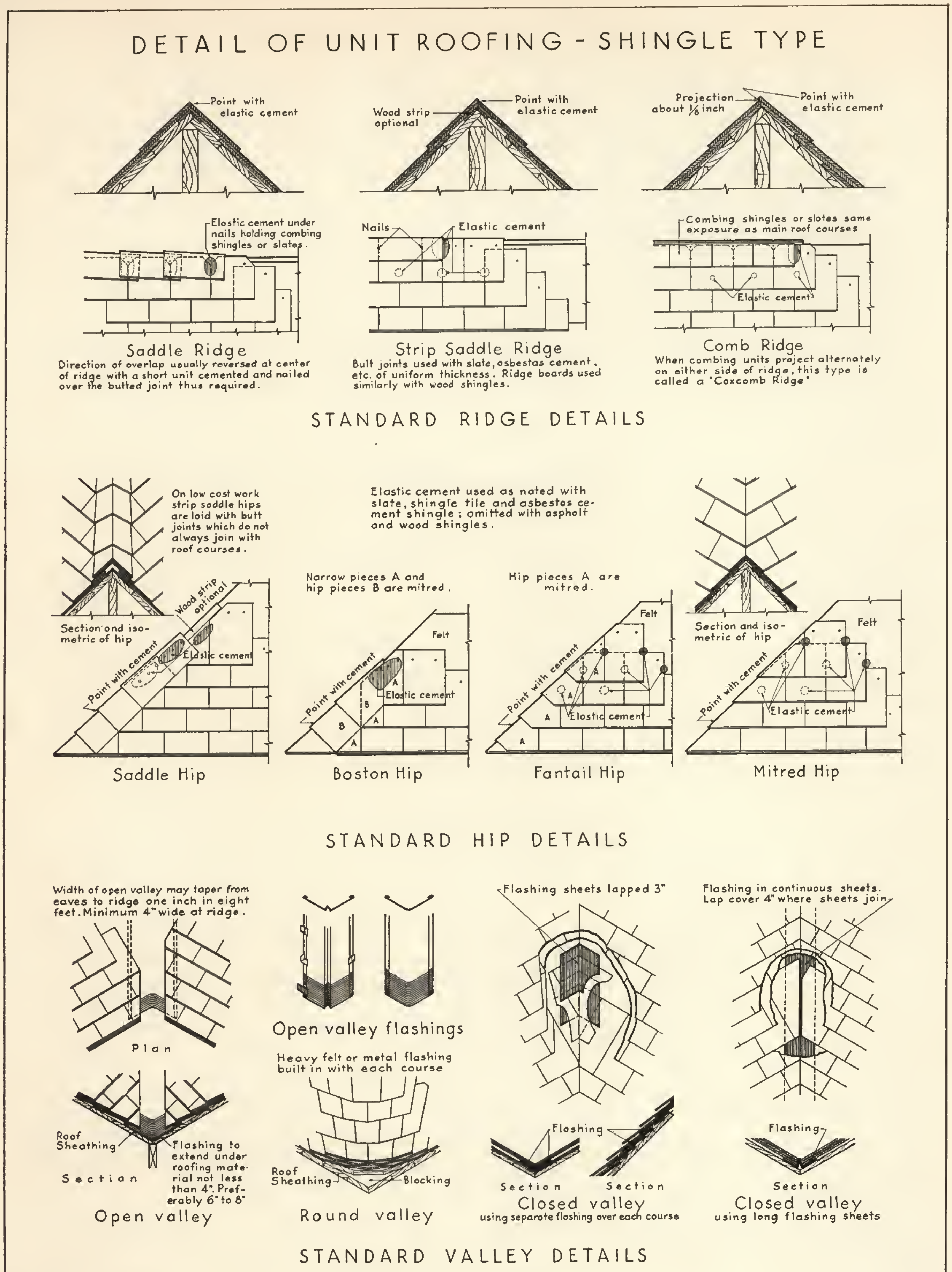

DETAIL OF UNIT ROOFING - SHINGLE TYPE
Point with elastic cement
Wood strip optional
Point with elastic cement
Projection about 1/8 inch
Point with elastic cement
Elastic cement under nails holding combing shingles or slates.
Nails
Elastic cement
Combing shingles or slates same exposure as main roof courses
Elastic cement
Saddle Ridge
Direction of overlap usually reversed at center of ridge with a short unit cemented and nailed over the butted joint thus required.
Strip Saddle Ridge
Butt joints used with slate, asbestos cement, etc. of uniform thickness. Ridge boards used similarly with wood shingles.
Comb Ridge
When combing units project alternately on either side of ridge, this type is called a "Coxcomb Ridge"
STANDARD RIDGE DETAILS
On low cost work strip saddle hips are laid with butt joints which do not always join with roof courses.
Elastic cement used as noted with slate, shingle tile and asbestos cement shingle; omitted with asphalt and wood shingles.
Wood strip optional
Section and isometric of hip
Point with cement
Elastic cement
Narrow pieces A and hip pieces B are mitred.
Felt
Point with cement
Elastic cement
Hip pieces A are mitred.
Felt
Point with cement
Elastic cement
Section and isometric of hip
Felt
Point with cement
Elastic cement
Saddle Hip
Boston Hip
Fantail Hip
Mitred Hip
STANDARD HIP DETAILS
Width of open valley may taper from eaves to ridge one inch in eight feet. Minimum 4" wide at ridge.
Plan
Open valley flashings
Heavy felt or metal flashing built in with each course
Flashing sheets lapped 3"
Flashing in continuous sheets. Lap cover 4" where sheets join.
Roof Sheathing
Flashing to extend under roofing material not less than 4". Preferably 6" to 8"
Section
Open valley
Roof Sheathing
Blocking
Round valley
Flashing
Section
Section
Closed valley
using separate flashing over each course
Flashing
Section
Closed valley
using long flashing sheets
STANDARD VALLEY DETAILS

FIGURE 1

Mission tile requires wood battens under the cover tiles to partly support their weight and to provide a nailing point. The lapping of interlocking tiles is established by the form of the tile itself. Usually the head lap is 3 inches. Shingle tiles are usually lapped like slate with a 2-inch head lap over the alternate courses beneath. See Table 4.

Cement roof tile are made in both shingle and Mission shapes. They are used chiefly in commercial work and are usually flat in shape and in sizes 12x 24″ and larger. They have interlocking side laps and usually interlocking head laps.

Glass tile are manufactured for use in conjunction with clay tiles of various types over open purlin construction to form skylights of minimum prominence on the roof. The tiles are wired to the purlins and are usually themselves reinforced after the manner of wired glass.

Metal tile are substantially lighter in weight than mineral tiles and have the same properties of endurance as are noted elsewhere for sheet metal roofs of the same materials. They are necessarily uniform in shape and have the mechanical regularity of a machine-made product and of interlocking clay and cement tile units. They permit the use of a lighter roof construction and usually a 15-lb. roofing felt is used over the deck.

Cast iron roofing tiles are made for industrial purposes and, like the large cement tiles of similar character, are usually laid directly on steel purlins spaced at proper intervals. All other types of tile roofing are laid on tight decks of wood or nailing compound.

METAL ROOFINGS

THERE are three basic types of metal roofings: flat sheet roofings assembled with seams of various types, corrugated sheet roofings, and unit roofings formed out of metals in the shape of Spanish tile, flat tile, or shingles. The principal metals used are copper, zinc, lead, aluminum, galvanized iron, tin-plate, terneplate, and cast iron.

SHEET METAL ROOFINGS

THE normal way of installing sheet metal roofs is to assemble on the roof individual sheets of limited size, using joints or seams of one of the types indicated in Fig. 2. Except on roofs having a pitch of 3 inches to the foot or less, the use of soldering or welding to assemble the sheets is minimized and confined largely to ridges and hips where the fitting of members cannot be done with a standard type of seam. The purpose is to allow adequate room for expansion and contraction under changes of temperature, for this inevitable movement constitutes the principal problem in the design of successful metal roofings. For the same reason as well as for water-tightness, none of the sheets are nailed directly to the root deck but are held in place with cleats of the same metal which are first nailed to the roof and then incorporated in an adjacent seam.

Inasmuch as electrolysis may develop between any two unlike metals, it is essential that the nails, cleats and other accessories be of the same metal as the main roof. Even aluminum nails are made for use with aluminum roofing, but copper nails may be used with lead roofing. Whenever two dissimilar metals come together they should be insulated from each other by (a) separating the metals with saturated felt, (b) separating the metals by a strip ot sheet lead, (c) heavily tinning the iron as is often done with iron or steel gutter and leader supports, or (d) coating both metals with bituminous paint.

The choice of seam is governed by considerations of appearance, the incline of the roof, and the coefficient of expansion of the metal in relation to the size of the entire roof area. Batten seams and standing seams provide for expansion and break up the monotony of an otherwise uniform metal roof. They should be spaced with some consideration to the scale of the building or the roof area. The standard dimensions given in Fig. 2 are normal, and the spacing of standing or batten seams should be computed according to the width of the metal sheets to minimize waste and extra labor of cutting.

Flat seams, soldered, may be used on slopes from ¼ to 3 inches per foot; unsoldered horizontal seams on steeper pitches. Standing seams may be used on slopes rising 2½ inches per foot or more. Batten seams may be used on slopes of 3 inches per foot and greater.

Sheet metal roofing practice has become too well standardized to require detailing here, and reference should be made to standard handbooks and to manuals of the various metals manufacturers.

Copper is made in two tempers: soft or roofing temper (abbreviated R. T.) for all roofing and flashing work wherever the shaped or formed work is supported, as in built-in or box-gutter linings, etc.; and hard or cornice temper (abbreviated C. T.), for hanging gutters, eaves, troughs, leaders, cornices, unit shingles, or wherever stiffness is necessary to support or maintain the shape of the work.

For all ordinary roofing work and flashings not less than 16-oz. copper is employed. Heavier metal of 20 or 24-oz. weight should be used for flashings in heavy tile roofs, particularly Mission tile, where the shape causes drainage to strike the flashings in concentrated streams. Avoid use of copper sheets or pans under the concentrated fall of quantities of water to minimize erosion.

Roofing copper is stocked in sheets which are multiples of 2 inches in width and 96 inches in length. The expansion of copper is more than that of iron or steel but less than that of other roofing metals. Normally, the vertical seams—particularly the standing or batten seams—provide adequately for temperature movement. When a flat deck is to be roofed with copper and all joints must be soldered, sheets 14″x20″ should be used and held to the roof with three copper cleats to the sheet. Expansion is taken care of by slight bulging of the

sheets, but contraction requires that runs longer than 30 or 40 feet be provided with expansion joints. Such joints should also be specified at the high point of gutters if the runs exceed 70 feet with free ends or 40 feet where movement is limited.

Lead-coated copper has the strength and relatively light weight of copper and the enduring gray color of lead. It may be used with leadwork (see lead roofing) but its installation should follow sheet copper practise.

Lead, like copper, is made in two kinds: soft lead, manufactured according to A. S. T. M. specifications, and hard lead, containing 6 to 7½ per cent antimony which gives it greater stiffness and strength, and permits use of thinner material. Weights commonly used are: hard lead, 2½ to 3 lbs. per square foot, (5/128 to 3/64 inch thick); soft lead, 4 to 6 lbs. per square foot, (1/16 to 3/32 inch thick). The lighter weights of each material should be used only for small roofs where battens are spaced 24 inches or less on centers, or for cap flashings; the heavier sheets should be used for roofing, base flashings and gutter linings.

Lead has a considerably greater coefficient of expansion than copper and therefore should never be confined so that it cannot expand and contract freely. Roofs may be either batten or standing seam type. Sheets not larger than 2'x4' should be used except in special cases, and cleats should always be employed for attachment to the roof deck. Preferably seams should come every 18 inches. Always specify a 30 or 40 lb. roofing felt to be laid under the lead.

Aluminum roofing is commercially pure metal of 18 gauge thickness weighing .568 lbs. per square foot. Its color is a lead-toned gray (not the bright color familiar in the polished metal). It is an enduring material, the maximum life of which is unknown.

Aluminum is used over a 30-lb. asphalt saturated felt and should always be protected by insulation from dissimilar metals by such felt or by painting with bituminous paint. Also use bituminous paint on aluminum flashings embedded in mortar joints or against concrete.

Sheet aluminum roofing can be applied on any slope not less than 3 inches to the foot, using batten seams with either wood or aluminum battens, or standing seams. Wood battens should not be spaced farther apart than 24 inches and should be worked out to allow the use of aluminum stock sheets as given in Table 2. Special aluminum battens are available with extruded cap sections. The expansion of aluminum is between that of copper and lead and should be amply provided for in the design of seams. The manufacturer's recommendation for proper temper and gauge for the sheet should always be observed. Soldered joints should never be attempted, and welded joints used only when essential. Lap seams not welded should lap at least 4 inches.

Galvanized iron, tin and terneplate roofings may be considered together because their treatment is substantially the same. Standard installation practice is found in all handbooks and is well understood.

Galvanized iron roofing should not be painted until it has been exposed to the atmosphere for a year or more, or until it shows rust spots. The reason for this is that the sal ammoniac remaining on the sheet after galvanizing prevents the adhesion of paint. This must be cleaned off with a diluted acetic acid if paint is to be applied before it has been removed by the action of the elements. Painted sheet metal roofing, however, should be painted immediately after application as it is only prime coated at the mill, and all painted metal roofs should be repainted every five years.

Zinc makes an enduring roof under most conditions of service and is used after the manner of copper and aluminum, with the exception that it is not recommended for flat roof decks. It is a more brittle metal requiring the use of an especially ductile roof sheet for successfully forming the seams. The following characteristics should be noted:

Zinc gauges are not the same as those used with other metals. Low numbers in zinc gauge represent the thinner sheets while low numbers in Brown & Sharpe and U. S. Standard gauges represent the heavier sheets. Therefore, always designate thickness in "zinc gauge" or in decimal parts of an inch. The standard roofing zinc is No. 11 zinc gauge, equivalent to No. 22 B & S, or .024 inch.

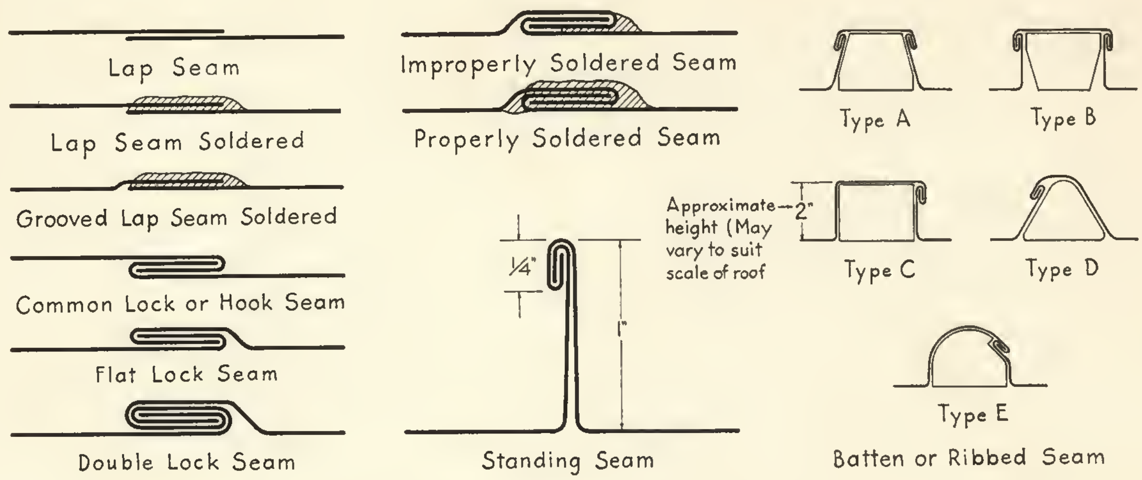
Do not use zinc with redwood, red cedar or oak. This excludes the use of zinc roofing or flashings in conjunction with most wood shingle roofs.

Zinc has the greatest coefficient of expansion among roofing metals, exceeding lead; hence maximum provision should be made for expansion and contraction by avoiding soldered joints, by the use of standing seam or batten seam construction, and where battens are employed, by providing a heavy undercut to permit movement. If battens are spaced over 18 inches apart, increase the weight of metal to 12 to 15 zinc gauge as recommended by the manufacturer. Use a good quality saturated and coated waterproof sheathing paper which is chemically neutral and has a glossy surface (not ordinary tar paper) between the zinc and the roof deck.

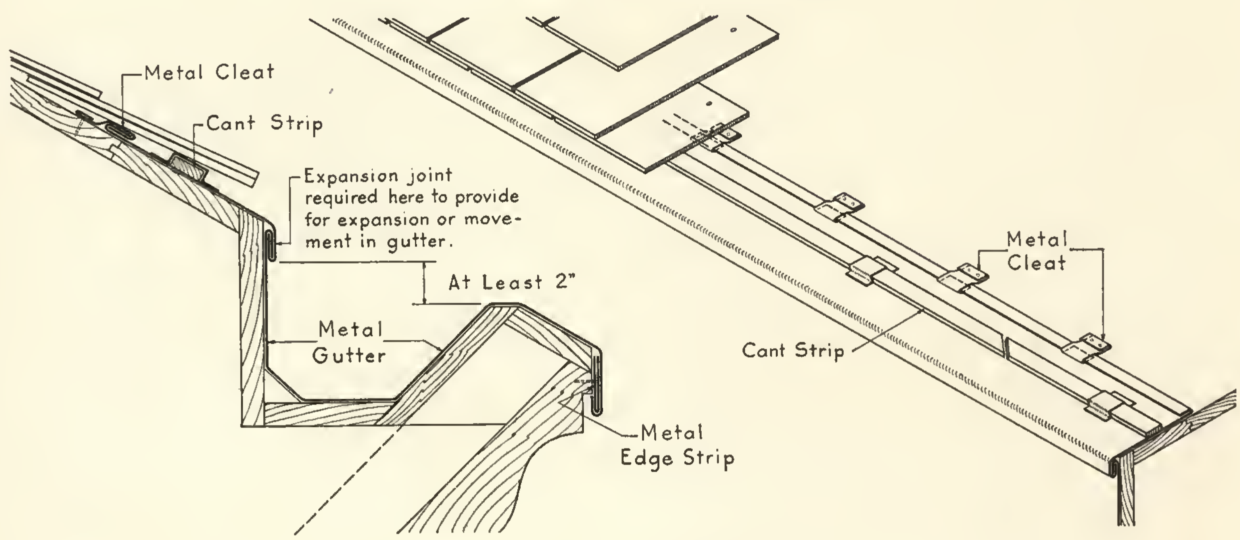
CORRUGATED METAL ROOFINGS

WHILE primarily employed for industrial buildings, warehouses and other structures not frequently within the scope of architectural practice, corrugated metal roofings constitute an important classification. The principal metals used are galvanized iron (preferably copper-bearing); iron protected with asphalt and felt coatings and sometimes thin copper surface coatings applied in process of manufacture; copper; zinc; and aluminum. Standard practice in the application of corrugated roofings may be obtained from handbooks or from manufacturers' manuals. A non-metallic form is made of asbestos cement sheets.

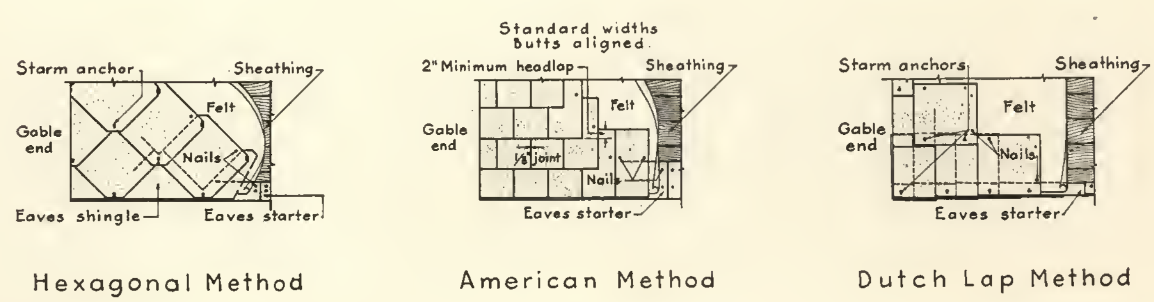
ROOFING DETAILS



STANDARD SEAM DETAILS



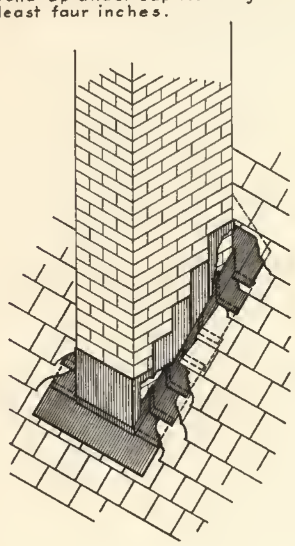
METAL BOX GUTTER



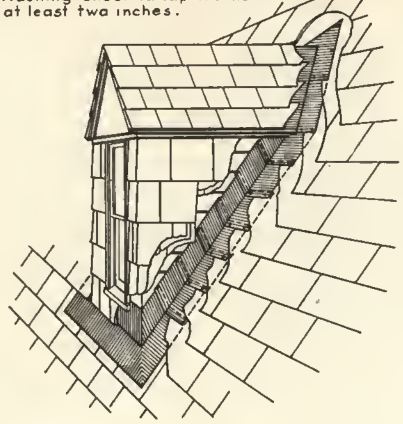
METHODS OF LAYING CEMENT AND COMPOSITION SHINGLES

FIGURE 2

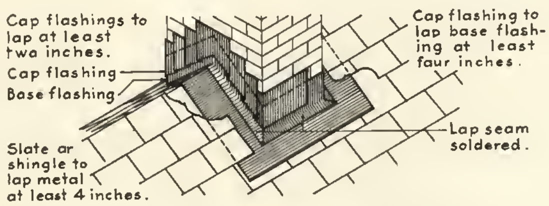
ROOFING DETAILS



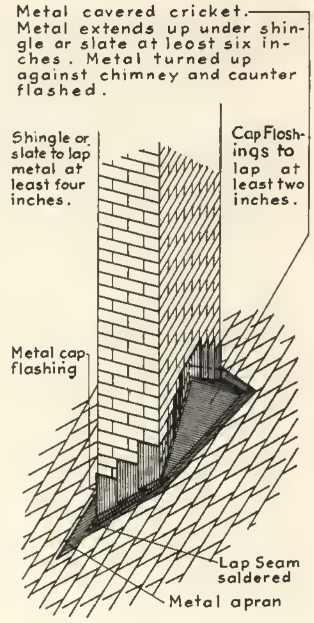
Built-in base flashing for chimney on slope



Built-in base flashing for dormer window

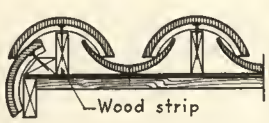


Flashing for chimney on ridge

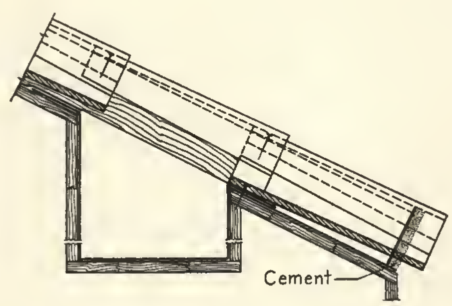


Flashing for chimney on slope

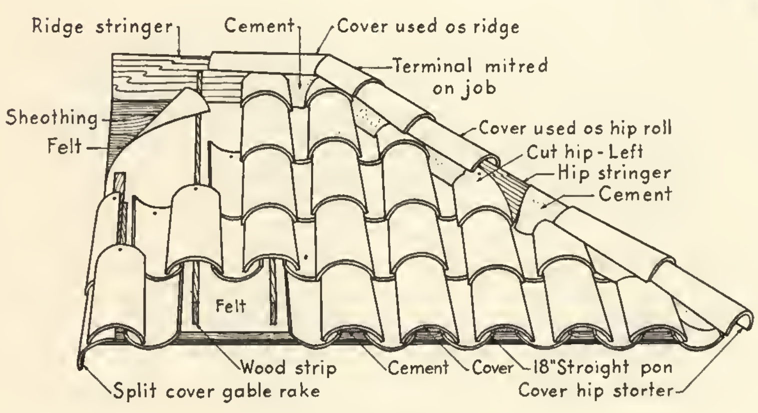
STANDARD FLASHING DETAILS



Section showing split cover gable rake



Section showing cover over concealed gutter
Pan is omitted



Elevation

MISSION TILE DETAILS

FIGURE 3

FLAT AND LOW-PITCH ROOFS

IF the modernists are entirely right in their precepts, eventually all American buildings will have "flat" roof decks on the functional grounds that they are least expensive to construct and provide useful areas which have hitherto been neglected. Without arguing the merits or fallacies of this trend, it is quite obvious that the so-called flat deck or very low pitched roof is steadily growing in architectural importance and hence deserves special consideration.

The lack of standard nomenclature and the often conflicting claims and implications of competing manufacturers have brought confusion into this important field. The misuse of the words tar, asphalt, pitch and bitumen in specifications has sometimes resulted in securing the wrong type of roof for given conditions because the architect and roofing contractor have not understood the terms the same way.

In the hands of reputable built-up roofing manufacturers and contractors, this looseness of terminology has resulted in no harm, for such organizations have provided the correct material in order to protect their own reputations and to justify the offer of a bond guaranteeing the life of the roof for anywhere from ten to twenty years. The architect's greatest safeguard is still to insist upon accepting the proposals of only the most reputable roofing contractors, for all authorities agree that workmanship is of as much importance as material in determining the life of otherwise similar built-up roofs and that skilled and rigid supervision is a large factor in assuring satisfactory performance.

In all cases, the architect should so prepare his specifications that when the roofing contractor has been selected, the detailed specifications and installation methods recommended by the manufacturer of the products used shall be followed without any deviation whatsoever. Otherwise no guarantees can be enforced.

However, the most satisfactory assurance of good results is to be had if the architect understands the different characteristics and uses of the component materials and employs this knowledge to select in the beginning the correct types of built-up roofing for each part of his structure.

Bitumen should be used only as a generic term to embrace all asphalts, tars and pitches used in roofing.

Asphalt may be used to designate "natural (lake) asphalt" or petroleum (steam-distilled and blown-oil) asphalts or either type with various admixtures and should be used with a qualifying adjective if a particular product is desired. Both types are compounded to meet various roofing requirements and both are used on sloping roof decks because they have less tendency to sag or run under sun heat than coal-tar pitch. Technically the differences are chiefly that "natural" asphalt is somewhat more adhesive, more ductile and slower to oxidize and develop "cheesiness" than oxidized or blown-oil asphalt and it possesses some self-healing properties not common to the petroleum product. By self-healing is meant the ability to flow together and amalgamate after a crack has been formed; a property highly desirable in flat deck roofs but usually so accompanied by a tendency to sag or run under summer sun temperatures that it can seldom be relied upon in materials suitable for roofs inclined more than two or three inches to the foot.

Various solvents and fillers are used in compound ing both types to form brushing asphalts, asphaltic cements, etc.; but for all built-up roofing work asphalts are applied hot and are solids at all temperatures naturally developed on roofs. The technology of bituminous products is so complex that architects must rely upon the experience and dependability of the manufacturer or roofing contractor unless they are prepared to test the products offered against such standards as those of the American Society for Testing Materials or Federal Specifications.

Pitch should be used to designate *coal-tar pitch* as distinguished from an asphaltic compound. Non-technically, coal-tar pitch is softer, has a lower melting point and greater resistance to water than asphalt and in addition is self-healing on "flat" roof decks. Therefore it is suitable for roof inclines sloping less than three inches per foot and seldom may be used on steeper inclines. Asphalts of suitable composition *may* be used on either sloping or flat decks but are not necessarily superior to coal-tar pitch on flat decks.

In comparing these two products non-technically it may be further noted that the natural self-healing property of coal-tar pitch is a distinct asset on roofs sloping so little that the pitch will not run off under sun heat. At the same time this low melting point may cause trouble on wood roof decks if the planking is not tight or the under felts sufficiently absorbent to prevent dripping through the deck in very hot weather. Under such conditions a higher melting point asphalt would be clearly indicated.

Tar should be used to denote a coal-tar product of a more volatile nature than coal-tar pitch from which the latter is produced by modern tar distillation processes. It is used in compounding coal-tar pitches and so-called "gums" of various types and for saturating felts that are used with coal-tar pitch bitumens. It is incorrect to use tar as a generic term embracing either asphalt or pitch roofings, or to use tar paper or tarred felt to indicate an asphalt saturated felt instead of a coal-tar felt or paper.

These terms are developed in detail here because of the need for greater clarity when specifying roofing types and roofing compounds. The technologist would go much further in distinguishing between these products and would note various compounds and blends which are not enumerated here. For all practical purposes adherence to these general distinctions will serve to clarify the architect's designation of built-up roofing materials.

Felts used for built-up roofings include dry or unsaturated felt, asphalt saturated felt, and coal-tar

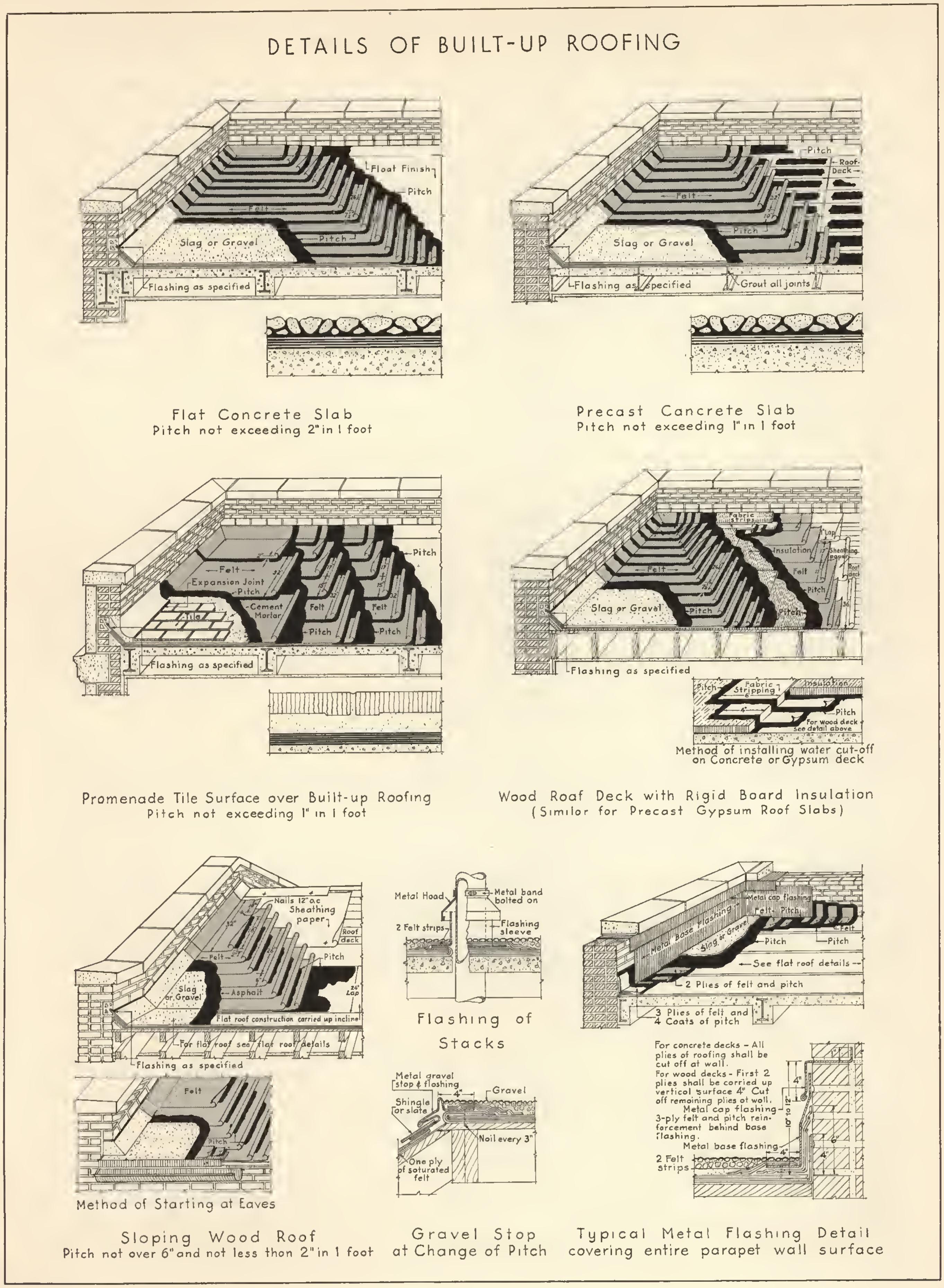

DETAILS OF BUILT-UP ROOFING
Float Finish
Pitch
Felt
Slag or Gravel
Flashing as specified
Flat Concrete Slab
Pitch not exceeding 2" in 1 foot
Roof Deck
Grout all joints
Precast Concrete Slab
Pitch not exceeding 1" in 1 foot
Expansion Joint
Cement Mortar
Tile
Promenade Tile Surface over Built-up Roofing
Pitch not exceeding 1" in 1 foot
Fabric strips
Insulation
Sheathing paper
Fabric Stripping
For wood deck see detail above
Method of installing water cut-off on Concrete or Gypsum deck
Wood Roof Deck with Rigid Board Insulation
(Similar for Precast Gypsum Roof Slabs)
Nails 12" oc
Sheathing paper
Asphalt
Flat roof construction carried up incline
For flat roof see flat roof details
Method of Starting at Eaves
Sloping Wood Roof
Pitch not over 6" and not less than 2" in 1 foot
Metal Hood
Metal band bolted on
2 Felt strips
Flashing sleeve
Flashing of Stacks
Metal gravel stop & flashing
Gravel
Shingle or slate
Nail every 3"
One ply of saturated felt
Gravel Stop at Change of Pitch
Metal cap flashing
Metal Base Flashing
See flat roof details
2 Plies of felt and pitch
3 Plies of felt and 4 Coats of pitch
For concrete decks - All plies of roofing shall be cut off at wall.
For wood decks - First 2 plies shall be carried up vertical surface 4" Cut off remaining plies at wall.
Metal cap flashing
3-ply felt and pitch reinforcement behind base flashing.
Metal base flashing
2 Felt strips
Typical Metal Flashing Detail covering entire parapet wall surface

FIGURE 4

saturated felt. The felts themselves are made of mineral fibers, such as asbestos; vegetable fibers, such as cotton, cellulose, and prepared wood; and mixed fibers including rag felts. The standard weights are 15 lbs. per square (single weight) and 30 lbs. per square (double weight), but extra heavy felts are used for special purposes up to 60 lbs. Normally the dry felts are used to separate an unstable roof deck, such as one consisting of wood plank or precast cement or gypsum blocks, and the roof membrane above. The saturated felts are used according to the bituminous cementing material mopped on the roof; that is, asphalt saturated felts for asphalt roofs and coal-tar saturated felts for pitch roofs.

Slag or gravel must be used on bituminous roofings employing coal-tar pitch to protect it from the drawing action of the sun and to minimize its tendency to flow. A coating of 300 lbs. of mineral slag or 400 lbs. of gravel to 100 sq. ft. of area is normally required. Slag or gravel is also frequently used on asphalt roofs for similar purposes; but when a smooth roof surfacing is desired or when the slope will not permit the retention of a slag or gravel surfacing, the bitumen should be of an asphalt nature. Gravel or slag for roofing purposes should be of such size that it will all be retained on an ⅛ inch sieve and all passed by a ¾ inch sieve, with not less than 80% passing a ⅝ inch sieve and retained on a ¼ inch sieve, according to Federal specifications.

Promenade tile and slate are used as a top surface in place of slag or gravel where the roof deck is to be used as a promenade or recreation area. Quarry tile one inch thick and in squares 6″ x 6″ and 9″ x 9″, or in rectangles 6″ x 9″ are employed where a smooth surface is desired. Slate paving units ¼ to 1 inch thick and in rectangles from 6″ x 6″ to 8″ x 12″ usually give a more textured effect. Either type of promenade surfacing can be laid over an asphalt or a coal-tar pitch built-up roof, using bedding compounds as recommended by the roofing manufacturer.

Construction details are broadly indicated in Fig. 4. No attempt is made in these diagrammatic drawings to represent all details of construction but to point out the slight differences in treatment which exist in different kinds of roof decks and on roofs of varying pitch. As noted elsewhere the architect should adhere strictly to the detailed specifications of the manufacturer of the selected roof.

When rigid fiber insulation boards are laid over the roof deck precautions should always be taken to seal the insulation by means of saturated felt and bitumen from contact with masonry surfaces such as parapets or walls. A similar water cutoff should be installed as shown in Fig. 4, right center, to protect insulation laid at the end of each day's work so that at no time is a built-up roof installed over damp insulation boards. Always use a felt and bitumen seal course beneath such insulations.

Durability of built-up roofing is usually governed by the number of layers or plies of felt and asphalt or pitch, and by the quality of materials and workmanship. Bonds offered by roofing manufacturers are relative indications of the durability of the roof. It may be safely assumed that the bond does not measure the maximum life of the roof but demands strict adherence to specifications that are based upon experience. For all practical purposes the use of suitable materials and proper workmanship in accordance with the manufacturer's specification will produce a roof having a life well in excess of the term of the bond offered.

Copper-clad built-up roofing is a comparatively new development. The materials used are usually a base of asphalt saturated felt and two or three layers of 2-oz. copper mopped between layers of hot asphalt and surfaced with a finish coating of hot mopped asphalt. Another variation employs 2-oz. copper bonded to a 15-lb. asphalt saturated asbestos felt.

OTHER SHEET ROOFINGS

Prepared roll roofings, sometimes called roll roofings, are made of three or more plies of felt saturated with asphalt or tar. Some are "smooth top," others surfaced with mineral granules like asphalt shingles. Tests at the Iowa State College indicate an average life for these roofings of ten years on roofs facing the south and 13½ years on roofs facing the north. They are chiefly used in architectural work for low pitched roof decks of limited area, in rural and remote suburban areas where it is impracticable to provide the asphalt or pitch melting and handling equipment required in the assembly of built-up composition roofs.

Canvas is sometimes used on low pitched roofs of small area and wood construction where more or less traffic is encountered that would injure a soldered sheet metal roof. Such conditions are commonly found on porch roofs in residences. Specially prepared canvas, which is available in several weights from light to extra heavy, is embedded in a thick lead and oil paste over a smoothly finished matched and tongued wood deck, and tacked with copper or heavy galvanized tacks along the lapped seams. Canvas is then painted with lead and oil paint, finished with a heavy top coat of yacht deck paint.

FLASHINGS

THE weather-tightness of any roof depends quite as much upon the correct design and installation of flashings as upon the construction of the main roof surface.

Copper is the preferred flashing metal for all roofs except those of other metals where the roofing metal should also be used for flashings. Minimum weight should be 16 oz. R. T.; for better work use 18 or 20 oz. and for under flashings of Mission tile or where there is a fall of water that might erode the copper, use 24 oz.

Zinc may be used in place of copper for all roofings except wood shingles. It should be laid over neutral saturated felts, held in place with clips rather than nails, and set in reglets with elastic cement. Use No. 11 zinc gauge or heavier.

Lead may be used with any roof, but usually is employed only on the most enduring roofs such as sheet lead, slate or clay tile. Use hard lead of 2½ or 3 lbs. weight.

Tin or **Terne-plate** may be used on low-cost work but is unsuited for long life roofs unless it can be repainted every three to five years. The base metal for flashings should be IX thickness (approximately 28 gauge U.S.S.), heavily coated.

Aluminum flashings are used with aluminum sheet metal or pressed shingle roofs according to manufacturers' detailed recommendations.

Bituminous flashings made of impregnated woven fabrics or felts or of construction similar to the roofing itself, are often used with built-up roofings. Unless extended into flashing blocks in masonry walls, cap flashings of copper are to be preferred over counter-flashings that depend upon asphaltic cements and roofing compounds for their permanent weather resistance. Always follow roofing manufacturers' recommendations.

Methods of installing flashings are well established in the roofing trade and need little detailing here. Typical methods of using flashings on unit roofings are shown in Figs. 2 and 3. In specifying flashings these points should be considered.

Install flashings at all intersections formed by the roof with vertical surfaces, at all changes of pitch (valleys, hips, ridges) unless the roofing be of continuous sheet type, wherever stacks, chimneys or other structures penetrate the roof, at the eaves, and at all points where water, snow or ice may collect and work under the joints formed by the roofing units.

Provide for expansion and contraction at all junctions of dissimilar constructions by means of cap flashings overlaying (but not fastened to) base flashings, and by means of suitable slip joints where the expansion and contraction of the metalwork develops appreciable movement, as in long valley flashings and where eave flashings join gutters.

Carry flashings under unit roofings in valleys and at eaves beyond the area in which any water, snow or ice may collect. Increase the size of flashings beyond standard practice whenever conditions may cause excessive accumulations of snow or ice.

In valleys formed by slopes of unequal pitch or height, where the water shed by one slope may develop greater velocity or volume than from the other, install a crimp, batten or other equivalent projection in the valley to act as a baffle that will prevent the heavier flow from washing beyond the flashed area on the flatter or shorter slope.

Never permit nailing through metal flashings except on sheet flashings in closed valleys and on ridges and hips where the nails are covered by the flashing above. In valleys and at eaves where large metal flashings are employed attach by means of cleats to permit movement.

Wherever flashings join masonry they should be carried into reglets cut into the masonry or its joints and caulked in place with lead or caulking compounds.

TABLE 5 — RAINFALL INTENSITIES AND DRAINAGE CAPACITIES OF LEADERS

	(A) Storms Which Should Be Exceeded Only Once in 5 Years		(B) Storms Which Should Be Exceeded Only Once in 10 Years		(C) Maximum Recorded Storms	
	Intensity in Ins/Hr. Lasting 5 Minutes	Sq. Ft. of Actual Roof Drained Per Sq. In. of Leader Area	Intensity in Ins/Hr. Lasting 5 Minutes	Sq. Ft. of Actual Roof Drained Per Sq. In. of Leader Area	Intensity in Ins/Hr. Lasting 5 Minutes	Sq. Ft. of Actual Roof Drained Per Sq. In. of Leader
Albany......	6	200	7	175	7	175
Atlanta......	7	175	7	175	9	130
Boston.......	5	240	6	200	7	175
Buffalo.......	5	240	5	240	10	120
Chicago......	6	200	7	175	7	175
Detroit.......	6	200	6	200	7	175
Duluth.......	5	240	6	200	7	175
Kansas City...	7	175	8	150	10	120
Knoxville.....	5	240	6	200	6	200
Louisville.....	6	200	7	175	8	150
Memphis.....	5	240	6	200	10	120
Montgomery..	7	175	7	175	7	175
New Orleans	7	175	7	175	8	150
New York...	6	200	8	150	9	130
Norfolk......	6	200	7	175	8	150
Philadelphia.	6	200	7	175	8	150
Pittsburgh.....	6	200	6	200	7	175
St. Louis......	6	200	8	150	11	110
St. Paul......	6	200	6	200	8	150
San Francisco.	2	600	2	600	3	400
Savannah.....	6	200	7	175	8	150
Seattle.......	2	600	2	600	2	600
Washington...	6	200	7	175	8	150

FROM COPPER AND BRASS RESEARCH ASSOCIATION

TABLE 6. DIMENSIONS OF STANDARD ROOF LEADERS

Type	Area in Sq. In.	Leader Size
Plain Round	7.07	3″
	12.57	4″
	19.63	5″
	28.27	6″
Corrugated Round	5.94	3″
	11.04	4″
	17.72	5″
	25.97	6″
Polygon Octagonal	6.36	3″
	11.30	4″
	17.65	5″
	25.40	6″
Square Corrugated	3.80	1¾″ x 2¼″ (2″)
	7.73	2⅜″ x 3¼″ (3″)
	11.70	2¾″ x 4¼″ (4″)
	18.75	3¾″ x 5″ (5″)
Plain Rectangular	3.94	1¾″ x 2¼″
	6.00	2″ x 3″
	8.00	2″ x 4″
	12.00	3″ x 4″
	20.00	4″ x 5″
	24.00	4″ x 6″

FROM COPPER AND BRASS RESEARCH ASSOCIATION

ROOF DRAINAGE

WHILE rainfall records showing the maximum intensity in inches per hour lasting five minutes are the basis for computing gutter and leader (or conductor) sizes for projects of major importance, experience has shown the adequacy of certain short-cut rules for designing these important roof elements.

Leaders should be not less than 3 inches round or 1¾" x 2¼" rectangular, except for small porches. Their area should be constant throughout their length and they should not be spaced over 75 feet apart. In small building work they should be placed near corners to avoid forcing water to flow far beyond a sharp turn.

Compute the areas tributary to each leader using the actual roof area rather than the plan area. Data given in the last column of Table 1 will assist in computing roof area from plan when pitch is known. From Table 5 take the factor indicating the "square feet of actual roof drained per square inch of leader area" for the conditions indicated in the nearest city. When an overflow may be permitted once in five years, use Column A. When a ten-year interval is acceptable use Column B. On roofs where overflow is to be avoided under any circumstance, use the maximum recorded storms in Column C. Divide the roof areas tributary to each leader by the factor thus found to determine the required areas of the leaders.

The actual leader size to be used will then be found in Table 6.

Gutters should have a minimum depth equal to one-half their width and a maximum depth not exceeding ¾ of the width. With this general proportion the width is the deciding factor in proportioning gutter size. Half round gutters are most economical and are properly proportioned. Other shapes should approximate their profile so far as possible, and in no case should be so steep sided as to be injured by the formation of ice.

Where the spacing of leaders is 50 feet or less, use a gutter of the same size if the leader be not less than 4 inches. For leader spacings exceeding 50 feet make the gutter width one inch wider than the leader diameter for every 20 feet or less of additional spacing on peaked roofs and for every 30 feet of additional gutter lengths for flat roofs.

INSULATION

ALL roofs should be insulated, with rare exceptions found in certain types of industrial plants. The roof area of most buildings is responsible for the greatest heat loss in the winter and for a large part of solar heat load in summer. Ordinary roof construction has less insulating value than any of the common side-wall constructions. Wood shingles alone of all roofing materials have an appreciable insulating value, especially if laid on tight sheathing, but this value is quite inadequate for satisfactory fuel economy in winter or comfort in summer.

There is an impression among some designers that slate is not a satisfactory roofing in southern climates because of the high heat absorption of stone. Slate has about the same conductivity as concrete, and if used without insulation or ventilation would prove troublesome in hot climates. But all roofs should be insulated with other materials than the roofing surfaces. The difference in the amount of insulation required with various mineral roofing materials to afford the same protection against heat transfer is not often an important factor.

Normally insulation should be placed above the roof deck on flat roofs of all types and below the roof deck, either between or below the rafters, on all sloping roof construction employing unit roofing materials. The reason for this is that all insulating materials must be kept dry, else they will lose all value and prove harmful. Adequate protection is not practical under unit roofings. Built-up membrane roofs afford this protection if properly laid. Above-deck insulation, thoroughly waterproofed at all points, prevents solar heat from reaching a heavy masonry roof so that the mass will not continually radiate heat within the structure during a protracted period of warm weather. For complete data on the selection, use and comparative value of insulating materials, see AMERICAN ARCHITECT Reference Data No. 11, "Thermal Insulation of Buildings," May, 1934.

VENTILATION OF ROOFS

REGARDLESS of the amount of insulation employed there is always a certain amount of heat transfer through the structure, insulation merely retarding the rate of flow rather than preventing it entirely. Hence any roof, insulated or otherwise, will heat up on warm, sunny days and radiate part of that heat to the space beneath the roof deck. The roof temperature may rise to as much as 140F during the daytime, creating a temperature head of 60 or 70F above that desired indoors. Part of this heat will be transferred indoors. At night the outdoor temperature and the roof surface may drop to 70F or less, but if the attic space has been warmed to 85 to 90F there is only a 10 to 20 degree temperature head between the indoor and outdoor surfaces which is insufficient to cool the attic space as rapidly as it heated.

Failure to appreciate this fact has led to many disappointments in the insulation of attic spaces, particularly in residences. The solution of the problem is always to provide ventilation for attic areas so that the increased temperature developed from solar heat can be quickly dissipated by the cooler night air. This ventilation may be effected by means of louvers, ventilators, false chimneys or continuous ridge ventilators shaped like ridge rolls or caps.

ETERNIT TIMBERTEX

To-day's Shingle Triumph

ETERNIT COLONIAL SIDING

This cypress textured siding in attractive "wood" colors banishes paint bills forever. Inexpensive and quickly applied. No chance to rot and absolutely fire-proof. When used over old siding, dead air space affords double insulation and saves fuel.

The Charm of Beautiful Cypress Wrought in Asbestos-Cement . . . Fire-proof, Rot-proof—Never Requires Paint

A new era of roofing beauty, safety, durability, and economy awaits your clients in Eternit Timbertex, a shingle of Ruberoid genius, and long wanted for dependable roofing, re-roofing and modernizing work.

This rot-proof, fire- and time-defying tapered Asbestos-Cement Shingle with its heavy butt reproduces the lovely texture of weathered cypress, aged and mellowed. Its several "wood" colors are soft, rich and lasting. Periodic painting or staining is never required, as the colors are an integral part of each shingle.

Roofing experts the nation over enthusiastically hail the amazing value-giving features of Eternit Timbertex as a solution to roofing up-keep. They marvel, too, at its remarkably low cost.

Investigate Eternit Timbertex, Today's Shingle Triumph. Samples gladly sent upon request.

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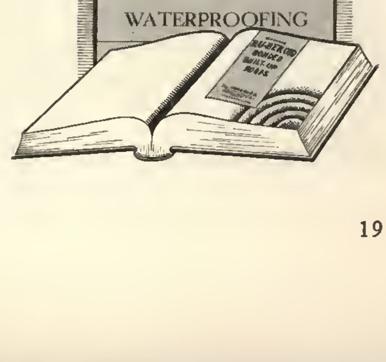

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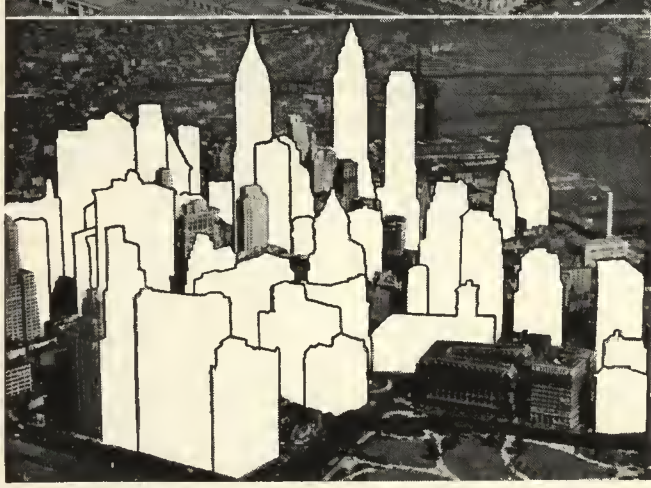
Lower Manhattan relies on Barrett for Roof Protection



Aerial Explorations Inc., N. Y. C.

Barrett ROOFS

Single out the prominent Barrett-roofed buildings (in white) in lower New York's famous sky-line and the amazing preference for Barrett Roof protection becomes strikingly evident... This is one of a series of advertisements illustrating that every fine building deserves — and usually gets — a Barrett Roof.

With striking unanimity, Barrett Roof protection is chosen for America's great buildings.

The owners of these buildings, and the architects and contractors who design and build them, know that Barrett Specification Roofs give them what they want above all else in roof protection—(1) a roof that won't leak, (2) a roof that won't need repairs, (3) a roof that is lastingly fire-safe, (4) a roof bonded by the U. S. Fidelity and Guaranty Company for periods up to 20 years, and (5) a roof that will continue to give trouble-free service years beyond the term of the bond.

Barrett Specification Roofs are applied only by Barrett Approved Roofers. There is one located near you. Consult with him or with us whether you have a new building to roof or an old one to reroof or repair.

THE BARRETT COMPANY, 40 RECTOR STREET, NEW YORK, N. Y.

2800 So. Sacramento Avenue, Chicago, Illinois   Birmingham, Alabama

A ROOF FOR EVERY BUILDING

One type of roofing will not meet all needs and that is why THE PHILIP CAREY COMPANY through more than sixty years of experience in the manufacture and application of roofing materials has developed a complete line of roofs. From the smallest temporary shed to the finest type of permanent construction you'll find a Carey Roof designed to meet your exact requirements.

No other ROOFING *has these* ADVANTAGES!

HERE'S a roof that sheds HEAT and COLD as well as water! Carey Cork Insulated Shingles combine weather protection and efficient insulation. A layer of cork added to the underside of the shingle provides an effective insulation that is automatically applied when the roof is put on—eliminating the extra cost of material and labor involved when separate insulation is used. Carey Cork Insulated Shingles will keep your home many degrees cooler in summer and correspondingly warmer in winter with a substantial saving in fuel bills.

They are extra thick—producing those deep shadow lines that add so much to the appearance of a roof and are available in colors to suit your individual taste.

Carey
CORK-INSULATED SHINGLES

ASBESTOS SHINGLES

Careystone—Asbestos-Cement Shingles—have that time-mellowed, weather-aged look that formerly only age could bring. Selected Portland Cement is reinforced with everlasting asbestos fibre and combined under great pressure into a permanent shingle possessing natural properties that enable it to resist the destructive influences of time, weather and fire.

ASPHALT SHINGLES

INDIVIDUAL TYPE . . .

Carey Asfaltslate Individual Shingles represent the standard of quality in composition shingles. Conventional in design with full three-thickness coverage to assure the maximum amount of roof protection. Carey Asfaltslate Shingles are built especially rugged and substantial to give extra years of trouble free service.

STRIP TYPE . . .

The manufacturing methods used to produce Carey Strip Shingles are the same as used in manufacturing Individual Carey Asphalt Shingles, except that in the final operation the finished shingle is cut into multi-units (2, 3 or 4 shingles in one strip). Carey Strip Shingles are offered in both the Hexagonal and Square Tab Styles and in weights and sizes to meet various requirements of service and cost.

PREPARED ROOFING

To meet the demand for a good, low-priced, quickly applied roofing material, THE PHILIP CAREY COMPANY offers a complete line of Prepared or Roll Roofing. Various weights and finishes are manufactured from best grade felts and asphalts.

CORRUGATED ROOFING AND SIDING

Made from Asbestos and Cement, Careystone Corrugated Asbestos-Cement Roofing and siding is a permanent material, possessing natural properties that enable it to resist the action of the elements and the many and varied destructive influences existing in most industrial plants.

BUILT-UP ROOFING

Every essential type of built-up roof construction, with definite recommendations as to the service adaptability of each is incorporated in *Carey's Twelve Master Built-Up Roofing Specifications.*

For complete specifications see Carey Catalogs filed in Sweets.

THE PHILIP CAREY COMPANY · LOCKLAND · CINCINNATI, OHIO

"To be really effective, INSULATION MUST BE THICK"

Eagle Home Insulation gives your clients wall-thick insulation at moderate cost!

• This is how Eagle Home Insulation is blown between joists in the attic floor by a special pneumatic method. The hose is run in through an open window. No muss downstairs.

● All authorities have come to the same conclusion. The *best* insulation is *thick* insulation. Not half-an-inch thick. Not one-inch thick. But *full wall thickness.*

Eagle Home Insulation provides this "wall-thick" insulation at moderate cost. Eagle Home Insulation is a soft, fluffy "wool" that is made from rock. It is blown between the joists in the attic floor and into the hollow spaces between wall studdings by a special pneumatic process. It packs evenly and will not settle. Trained operators do the work. In most homes the complete job takes from one to two days. No building alterations are necessary. And there is no mussing up inside.

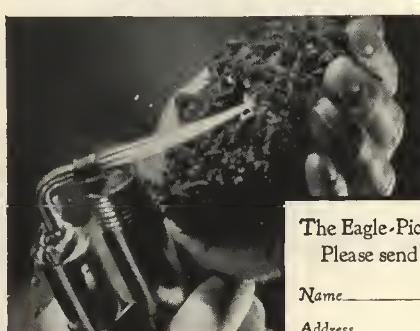
U. S. Bureau of Standards tests give Eagle Home Insulation the exceptionally low conductivity rating of 0.27 (at 103° F. mean temperature). In ordinary wall thickness (3⅝") Eagle Home Insulation has the insulating efficiency of a solid concrete barrier *eight feet thick.*

For free sample, mail the coupon below.

FOR COMPLETE DATA, SEE SWEET'S CATALOG

• No building alterations are necessary when Eagle Home Insulation is installed. To gain access to hollow spaces between wall studdings, operator removes a few pieces of siding, or a few bricks, or makes small openings in stucco.

• Eagle Home Insulation is also available in "bat" form for new construction. These bats are 15" by 18" and 3⅝" thick.



• Giving Eagle Home Insulation the fire test. Even when subjected to the flame of a blow torch, it does not char or burn. By filling hollow walls which ordinarily act as flues once a fire starts, Eagle Home Insulation provides real protection against the fire hazard.

EAGLE HOME INSULATION

BETTER HOUSING PROGRAM

• Boost the Better Housing Program in your community. It is creating new commissions for architects.

The Eagle-Picher Lead Company, Dept. AA-2, Cincinnati, O.
Please send me free samples of Eagle Home Insulation.

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MANY roofers all over the country have told us that this is the best . . . and truest . . . advertisement on roofing which they have ever seen. We believe that you, as an architect, will be interested in this.

These roofers are in a position to supply either coal tar pitch, or other types of roofing materials. But they know, from sad experiences the difficulties which come from laying anything but coal tar pitch roofings on flat decks.

If you are interested, we will be glad to send you a copy of a 4-page folder "Do's and Dont's on Roofing" which illustrates and analyzes the reasons for roofing failures.

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KOPPERS

A new set of 12 loose-leaf sheets of details on roofing, waterproofing, swimming pool construction, etc. by Don Graf, B.S., M. Arch., will be sent free to those who wish them.

Revere Products *for church roofs*

Old North Church, Boston.

"Beauty that endures" has been the traditional inspiration of church construction. Revere products have played a notable part in creating lasting beauty in American churches. The church buildings here illustrated are representative of a vast number of churches throughout America that have used Revere Copper in the last century and a quarter. The earliest was the Old North Church of Boston, sheathed with Revere Copper in 1805. One of the latest is the Cathedral of Assumption in Louisville.

Revere Sheet Copper and Revere Leadtex (the modern lead-coated sheet copper) were chosen because of their lasting beauty . . . a beauty that comes from mellow weathering, softer and deeper as the years advance. And of equal importance, Revere Copper was chosen for its permanence . . . because it assures protection from the weather and eliminates the repairs and replacements that inevitably follow the installation of rustable metals.

It is to your advantage to use Revere Copper for exterior work . . . for roofs, flashings, gutters, downspouts, and other sheet metal purposes. The long standing reputation of Revere for quality products assures your client's building of the ultimate in protection from the ravages of rust.

Revere Sheet Copper is extremely workable, too. It comes in Soft and Hard Tempers, and in a variety of finishes which will meet any requirement. Also of importance to you is Revere Leadtex which combines the light weight, easy workability, strength and durability of copper with the beauty of lead.

Revere Copper products are readily available through leading Sheet Metal Distributors.

St. Joseph's Church, Seattle. Architects: A. H. Albertson, J. P. W. Wilson, Paul Richardson.

St. Pascal's Church, Chicago. Architect: B. J. Hotton. Associate: Raymond Gregori.

Grace Evangelical Church, Oshkosh, Wisc. Architect: H. C. Haenser.

St. Paul's Lutheran Church, Milwaukee. Architect: Hugo Logemann.

Cathedral of Assumption, Louisville, Ky. Architect: D. X. Murphy and Bros.

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For thirty years and upward Genasco Standard Trinidad Built-Up Roofings have served this nation . . . have given lasting protection to commercial, industrial, institutional and public buildings in all parts of the country.

Genasco Standard Trinidad Built-Up Roofing is the only roofing of this type waterproofed with Trinidad Lake Roofing Asphalt. It is made from natural Trinidad Lake Asphalt — an intimate mixture of an extremely adhesive bitumen and an inherent mineral filler so dispersed in the asphalt by nature in the Trinidad Asphalt Lake as to be in colloidal suspension . . . therefore practically inseparable from the asphalt.

Trinidad Lake Roofing Asphalt is stable. It is most resistant to weathering, and is particularly valuable because it affords additional protection to roofing from the destructive action of the actinic or ultra violet rays of the sun—roofing's arch enemy.

You, too, like many other architects who have specified Genasco, can get roofs that give years and years of trouble-free protection.

You can get your copy of "For Your Roof" by filling out the coupon below.

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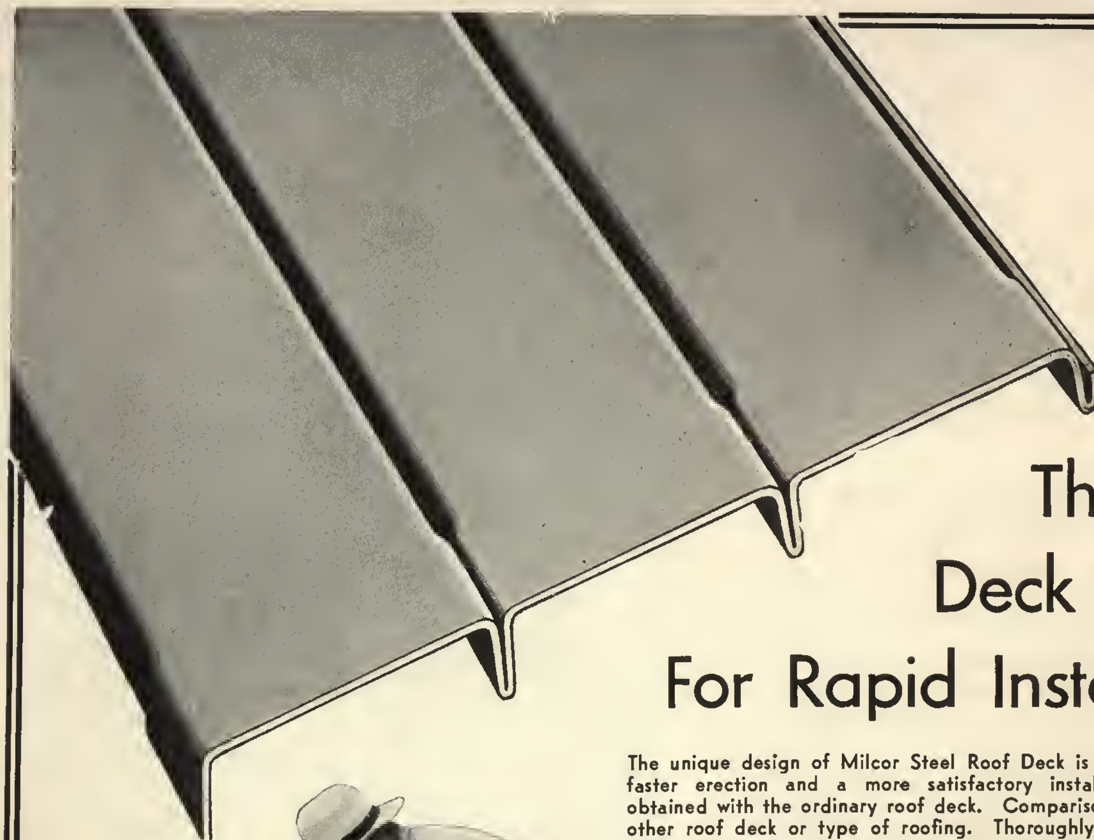

This Roof Deck Is Built For Rapid Installation

The unique design of Milcor Steel Roof Deck is responsible for much faster erection and a more satisfactory installation than can be obtained with the ordinary roof deck. Comparison is invited with any other roof deck or type of roofing. Thoroughly tested, Milcor Deck permits light steel construction with maximum load capacities.

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- Ribs depressed at one end for perfect lap.
- Depth of Ribs—1½ inches or 1¾ inches.
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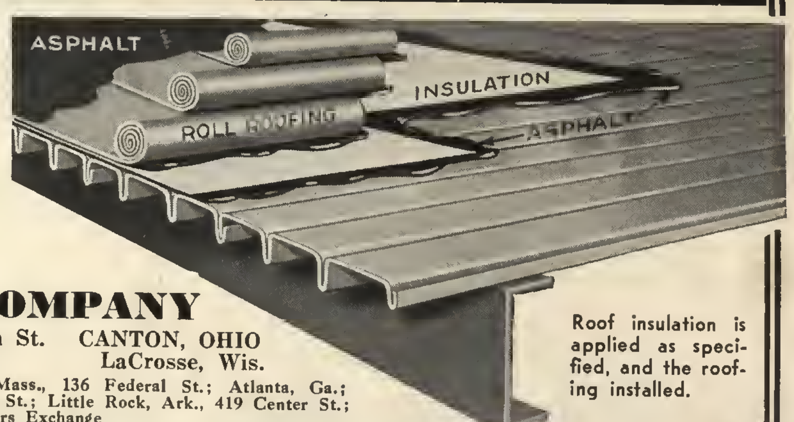
The unique offset in the illustration above facilitates nesting of ribs and assures a smooth, unbroken roof surface. Other outstanding advantages of this Roof Deck are its light weight, simple installation, neat appearance, fire safety and universal application.

Send for new illustrated circular!



Roof insulation is applied as specified, and the roofing installed.

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